KOOTENAI RIVER FISHERIES INVESTIGATION: STOCK STATUS OF BURBOT

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ABSTRACT

We captured a total of 44 burbot *Lota lota;* 29 in the Kootenai and Goat rivers, British Columbia (BC), Canada, and 15 in the Kootenai River and Boundary Creek, Idaho. Catch averaged one burbot every 33 net days of effort (a net day is a single net set for a 24 h period) for a total of 1,442 net days of effort. Burbot length ranged from 363 mm to 803 mm total length (TL) (mean = 541 mm, SE = 2.43); they weighed from 250 g to 3,125 g (mean = 1,137 g, SE = 15.21). A population estimate of 540 burbot (SE = 753) was made for the Kootenai River from Bonners Ferry to Kootenay Lake. The estimate was based on the capture of 130 fish and the recapture of nine from autumn 1995 through spring 1999. We monitored thirteen burbot that carried sonic or radio transmitters. Twelve burbot were implanted with transmitters during the study period, while one additional fish was a carry-over from the previous season. We requested a low flow (170 m^3/s) period of five weeks from the U S Army Corps of Engineers (USACE) to test the null hypothesis (H_o) that winter operation of Libby Dam does not affect burbot migration distance or travel rate. The test was requested to determine how far burbot could travel and the rate of travel (km/day) under a simulated pre-Libby Dam flow condition. The USACE provided a discharge period of five days at 170 m^3/s from Libby Dam. This low flow period was too brief for the study design and did not provide any conclusive information on travel distances of burbot. One larval burbot was caught in our sampling in the Kootenai River, downstream of the Goat River. Mitochondrial DNA (MtDNA) analysis of tissue samples from Duncan Lake, BC, indicated they were genetically similar to Kootenai River fish and a potential donor stock. We also hypothesize that high fluctuating flows from Libby Dam, which have continuously disrupted burbot migrations, may be responsible for the failure of burbot spawning. We recommend a laboratory study to test the physiological response of vitellogenin synthesis and ovulation of burbot to stress from high velocities and warmer temperatures.

INTRODUCTION

Burbot *Lota lota* in the Kootenai River (Figure 1) once provided an important winter fishery to residents of northern Idaho. Some anglers reported catching up to 40 burbot a night during winter setline fishing (Paragamian 1994). The annual harvest of burbot from the Kootenai River by sport and commercial fisherman in Idaho prior to 1972 may have been in the tens of thousands of kg. Three commercial anglers alone harvested an estimated 2,150 kg in 1958 (Idaho Department of Fish and Game [Department] Regional Archives). Burbot caught during the winter fishery are thought to have been part of a spawning migration from the lower river and Kootenay Lake in BC, Canada. However, after construction and operation of Libby Dam in 1972 by the USACE, the fishery rapidly declined and was closed in 1992. Concomitant to the collapse in Idaho was the collapse of the burbot fishery in Kootenay Lake, BC (Paragamian et al. 2000). Operation of Libby Dam for hydroelectric power and flood control has created major changes in the river's seasonal flow, particularly during the winter when burbot spawn (Figure 2). The temperature regime, and nutrient supply of the Kootenai River are also important and have changed (Partridge 1983; Snyder and Minshall 1996; Richards 1996).

The Kootenai River Fisheries Investigation was initiated in 1993 by the Department to address burbot abundance, distribution, size structure, reproductive success, movement, and to identify factors limiting burbot in the Kootenai River. Few burbot were captured between rkm 246 and the Montana border (rkm 275) from 1993 through 1994 (Paragamian 1994). There has been little evidence of reproduction in Idaho. Only one juvenile burbot was captured from 1993 to 1998, and no larval fish had been collected. However, numerous size-classes of burbot were in the catch, indicating some burbot were reproducing successfully. Previous studies had failed to document a spawning run of burbot from the lower river or Kootenay Lake, but cooperative sampling in the BC reach of the river with the Ministry of Environment Lands and Parks (MOELP) documented spawning burbot in the Goat River, BC.

Studies completed in the winter of 1997-1998 indicated flow management at Libby Dam likely affected burbot spawning migration during winter (Paragamian 2000). Movement of burbot with sonic transmitters was significantly higher ($P<0.01$) during low flow test conditions, which were designed to replicate pre-dam Kootenai River flow. Movement upstream was also significantly higher during low flow tests than the control ($P = 0.009$), despite the fact there were low flows during the controls. Winter flows are now three to four times greater than they were historically, when conditions were relatively stable. Daily differences in flow can now range up to 652 m^3/s. Fluctuating flows from Libby Dam, caused by hydropower production and floodwater evacuation, appear to have continuously disrupted upstream migrations of burbot. The specific effect of this disruption to burbot spawning migration and spawning is unknown, but it may have reduced spawning fitness or stamina and affected timing of burbot spawning. One or all of these possible factors could have been sufficient to reduce spawning success and recruitment to the fishery.

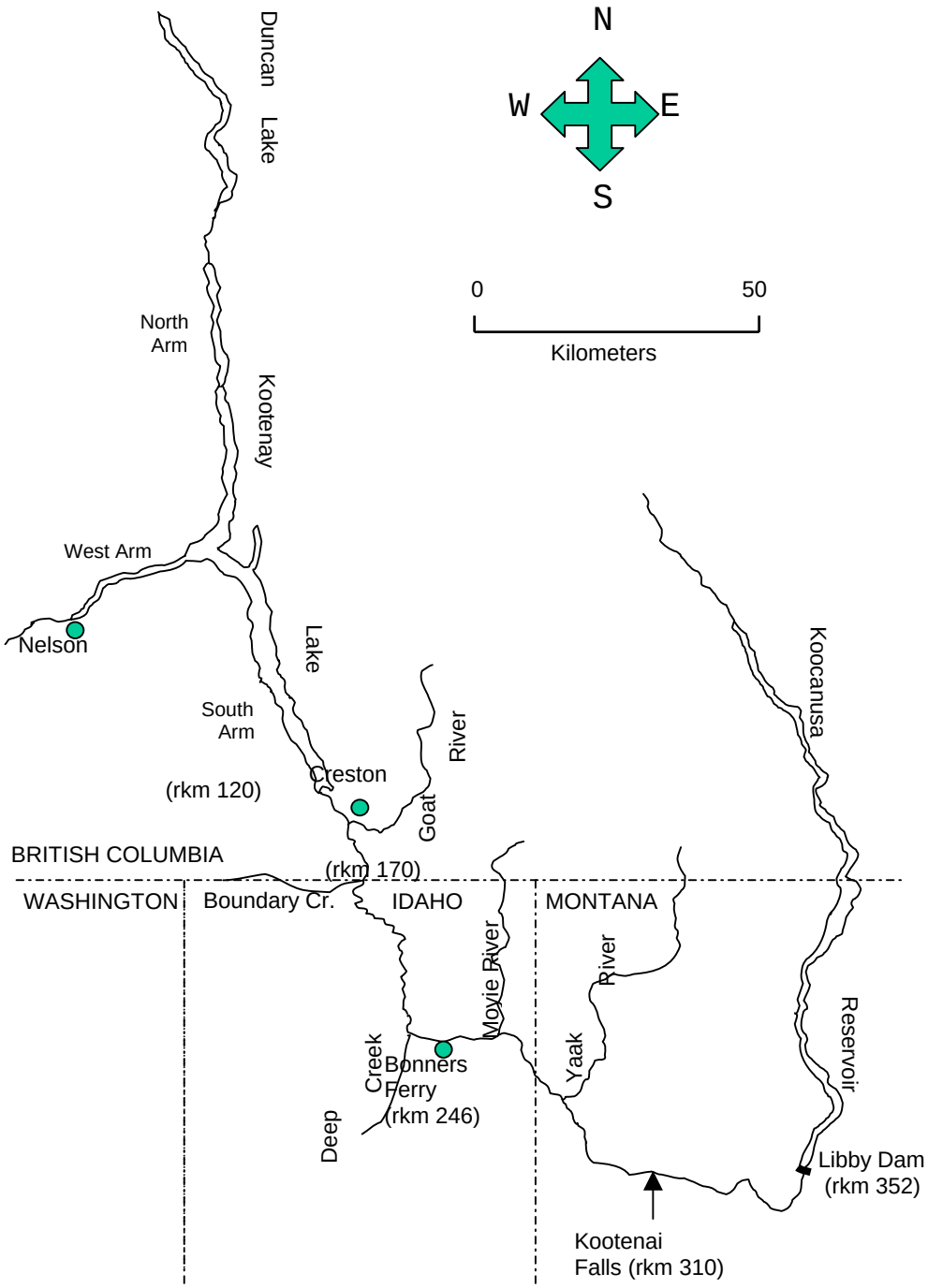

Figure 1. Location of the Kootenai River, Kootenay Lake, Lake Koocanusa, and major tributaries. The river distances from the northernmost reach of Kootenay Lake are in kilometers (rkm) and are indicated at important access points.

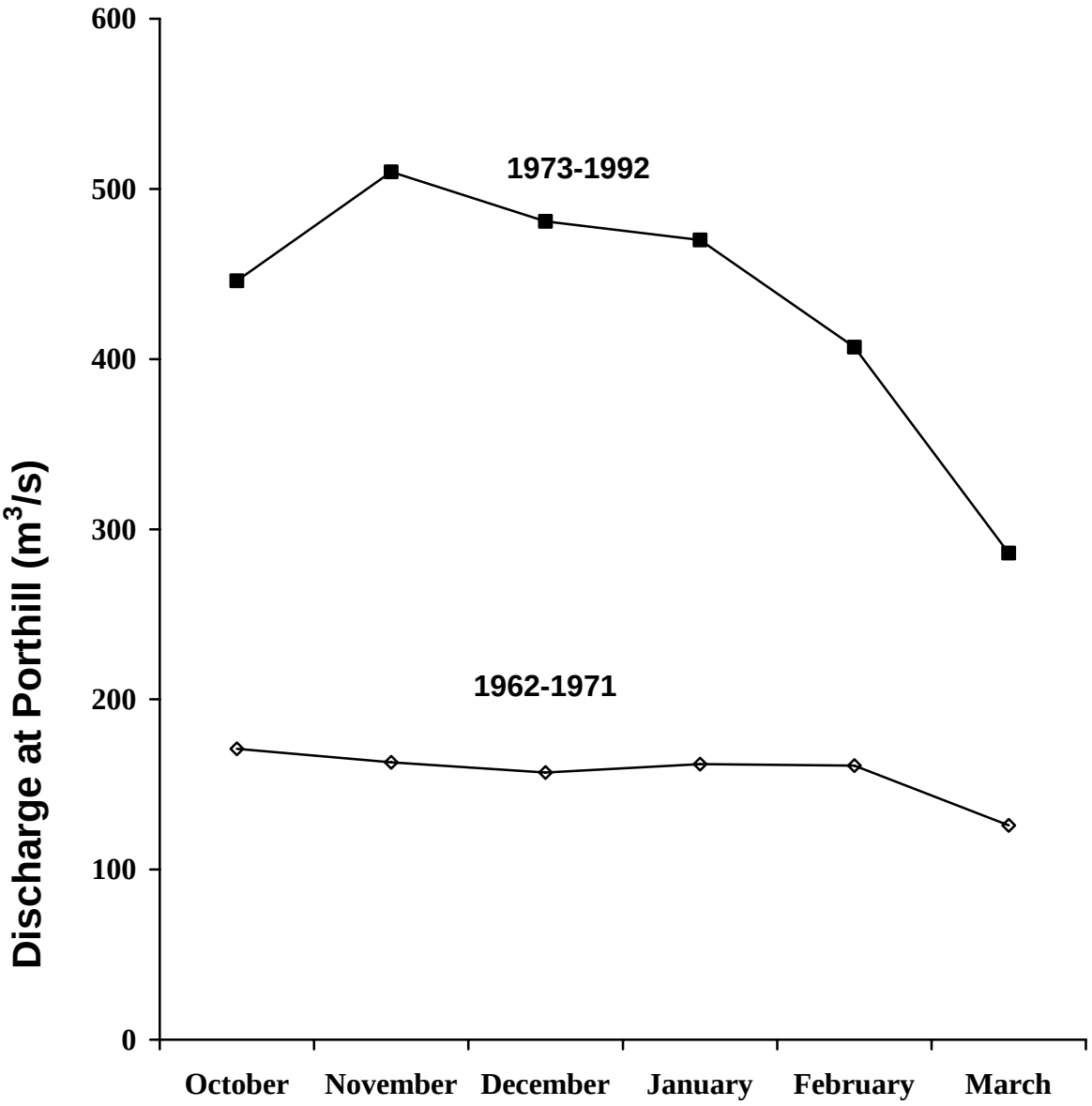

Figure 2. Mean monthly discharge of the Kootenai River at Porthill, Idaho, from 1962 through 1971 (pre-Libby Dam), and from 1973 through 1992 (post-Libby Dam).

GOAL

Restore the burbot population in the Idaho reach of the Kootenai River and improve fishing success to historic levels.

OBJECTIVES

1. Identify factors limiting burbot within the Idaho portion of the Kootenai River drainage and recommend management alternatives to restore the fishery to self-sustainable levels.

2. Define factors limiting burbot migration and reproductive success to improve survival and recruitment of young burbot.

3. Test the null hypothesis (H_o) that winter operation of Libby Dam does not affect burbot migration distance or travel rate.

STUDY AREA

The Kootenai River (spelled Kootenay for Canadian waters) is the second largest tributary to the Columbia River. Originating in Kootenay National Park, BC, the river flows south into Montana where Libby Dam impounds water into Canada and forms Lake Koocanusa (Figure 1). From Libby Dam the river flows west and then northwest into Idaho, then north into BC and Kootenay Lake. The Kootenai River at Porthill, Idaho, drains about 35,490 km^2. The reach in Idaho is 106 km long. Kootenay Lake drains out the West Arm and eventually the river joins the Columbia River near Castlegar, BC.

The Kootenai River presents three different channel and habitat types as it passes through Idaho. As the river enters Idaho, steep canyon walls and a gradient of about 0.6 m/km typify the corridor. The river begins a short braided reach about one km below the Moyie River, then at Bonners Ferry the river transitions to a lower gradient of approximately 0.02 m/km and meanders through a broad flood plain. Tributary streams of the Kootenai River are typically high gradient as they pass through mountain canyons but revert to lower gradients when they reach the valley floor, where most have been channelized.

METHODS

Discharge and Temperature

A conditional agreement was formulated with Bonneville Power Administration (BPA) and USACE to provide an experimental low flow test of 170 m^3/s for burbot spawning migration. Our intention was to test the null hypothesis that winter operation of Libby Dam does not inhibit burbot migration distance or travel rate. We hypothesized this minimum flow test would replicate pre-dam winter flow conditions and provide conditions for burbot to move significantly farther and faster upstream than previous years of study.

Daily discharge and temperature values for the Kootenai River were obtained from the USACE and the U S Geological Survey (USGS) office in Sandpoint, Idaho. Hobo and Stowaway XI temperature loggers were used to monitor daily water temperatures for Smith and Boundary creeks in Idaho, Summit Creek and Goat River in BC, and the Kootenai River at Porthill, Idaho, from October 1998 through March 1999.

Sampling Adult Burbot

We collected burbot from October 1, 1998 through April 12, 1999 using two to 13 hoop nets. Hoop nets had a maximum diameter of 0.61 m (see Paragamian 1995 for a description of the nets and the method of deployment). Nets were deployed in deep (usually the thalweg) areas of the Kootenai River between Ambush Rock (rkm 244) near Bonners Ferry, Idaho and Nick's Island (rkm 144) near Creston, BC, a distance of approximately 100 km. We also sampled two tributary streams including Boundary Creek, which enters the Kootenai River at Porthill, Idaho (rkm 170), and the Goat River, near Creston, BC (rkm 152).

Nets were usually lifted on Monday, Wednesday, and Friday of each week. Fish captured in hoop nets were identified by species, enumerated, measured for total length (TL), and weighed to the nearest gram (g). All burbot were implanted with passive integrated transponder (PIT) tags in the left opercular muscle and a small piece of pelvic fin tissue was collected for genetic analysis and archiving. Relative weights (W_r; Fisher et al. 1996) was calculated for all burbot captured.

Burbot Telemetry

Sonic and radio transmitters were used to track adult burbot movements during the year. Radio transmitters with a life expectancy of approximately 130 days were surgically implanted using methods similar to Hart and Summerfelt (1975). Radio transmitters were 11 mm in diameter, 28 mm in length, and weighed 10.53 g. Radios were programmed to be on for eight h and off for 16 h. Sonic transmitters had a 420-day life expectancy, were cylindrical in shape, and measured 18 mm by 65 mm and weighed 8 g (420 day transmitter). Sonic transmitters were either surgically implanted (see Paragamian 1995 for a description of the surgical procedures), or attached

externally using long hypodermic needles to run thin stainless steel cable through the dorsal plane and transmitter, which were then fastened with brass connector sleeves. When possible, sex of each burbot was determined during surgery.

Seasonal habitat use and movement of burbot were studied from September 1, 1998 through August 31, 1999. The primary period of study was from early November through February. Sonic telemetry was conducted primarily from a boat on alternate days of net lifting and occasionally on the same day as net lifts. Radio transmitters were tracked primarily from a boat and occasionally from a fixed-wing aircraft. When burbot were located by telemetry, the location was recorded to the nearest 0.1 rkm, depth was measured with a digital echo sounder, and nose velocity was measured (when possible) within 15 cm of the bottom using a Marsh-McBirney 2000 SVC electronic current meter.

Larval Sampling

Larval burbot sampling was conducted from March 11 through May 18, 1999 using paired ½-meter nets (mouth area = 0.7854 m^2) towed at the surface. Gurley 2030 R current meters were mounted in the mouth of each net and tows were made in a downstream direction. Tows were made in the Kootenai River from Smith Creek (rkm 178) to Nick's Island (rkm 144), the Goat River, and the North Arm of Kootenay Lake (rkm 14-18). Effort was calculated using total towing time and rotation counts per second from the flow meters x mouth area (0.7854 m^2) to calculate the total volume of water filtered through each net.

Population Estimate of Burbot

Population estimates of adult burbot were calculated using four years of mark and recapture data and a computer generated Cormack-Jolly-Seber model A (Ricker 1975). We used the mark and recapture data from autumn 1995 through spring 1999. The model can also provide an estimate of survival but only with an adequate sample size. The model also includes a sampling effort variable. The population estimate of adult burbot included the Kootenai River from Bonners Ferry downstream to Kootenay Lake, BC. All burbot used in the population estimate were captured in the river, but some burbot are known to move freely between the river and the lake. The Cormack-Jolly-Seber model does not provide an estimate for the first or last year of mark and recapture.

Duncan Lake Burbot Genetic Analysis

A cooperative search for a donor stock for the recovery of burbot in the Kootenai River was continued through the 1998-1999 period of study. The BC MOELP fisheries staff collected tissue samples of burbot captured in Duncan Lake, BC. Tissue samples were sent to the University of

Idaho Aquaculture Research Institute for mtDNA analysis. Methods of analysis were similar to those presented in Paragamian et al. (1999).

RESULTS

Discharge and Temperature

Kootenai River Discharge

Flow from Libby Dam ranged from about 113 m^3/s to 227 m^3/s from October 1 through November 30, 1998 (Figure 3). Flow from Libby Dam on December 1, 1998 was ramped up from 113 m^3/s to 581 m^3/s; flow thereafter ranged from 283 m^3/s to 737 m^3/s. The USACE provided a single five-day period of 170 m^3/s beginning January 20, 1999 for the null hypothesis test (Figure 3). On January 25 flow was ramped up, reaching a maximum of 663 m^3/s February 11, 1999. Flow from Libby Dam was gradually ramped down the first week in March 1999. By March 11 flow from Libby Dam was at the minimum protected flow of 113 m^3/s and remained at that level through June 14, 1999 (when white sturgeon spawning flows were requested).

Kootenai River Temperature

Temperatures in the Kootenai River and tributaries ranged from a low of 1.4^oC on January 27, 1999 to a high of 11.4^oC on October 15 and 16, 1998 (Figure 4).

Tributary Discharges

On January 25, 1999 stream flow in Boundary Creek was calculated at 2.19 m^3/s. Smith Creek flow on January 26, 1999 was 1.1 m^3/s. Summit Creek flow was calculated at 3.13 m^3/s on January 29, Corn Creek was 0.24 m^3/s on January 27, and the Goat River was 4.43 m^3/s on January 24, 1999.

Tributary Temperatures

Thermographs monitored water temperatures in two Idaho tributaries to the Kootenai River. Boundary Creek temperatures ranged from 0.0^oC during late December 1998 and early January 1999 to 8.0^oC on October 15, 1998 (Figure 5). Smith Creek temperatures were 0.0^oC during late December 1998 and warmest on October 15, 1998 when they reached 7.5^oC (Figure 5).

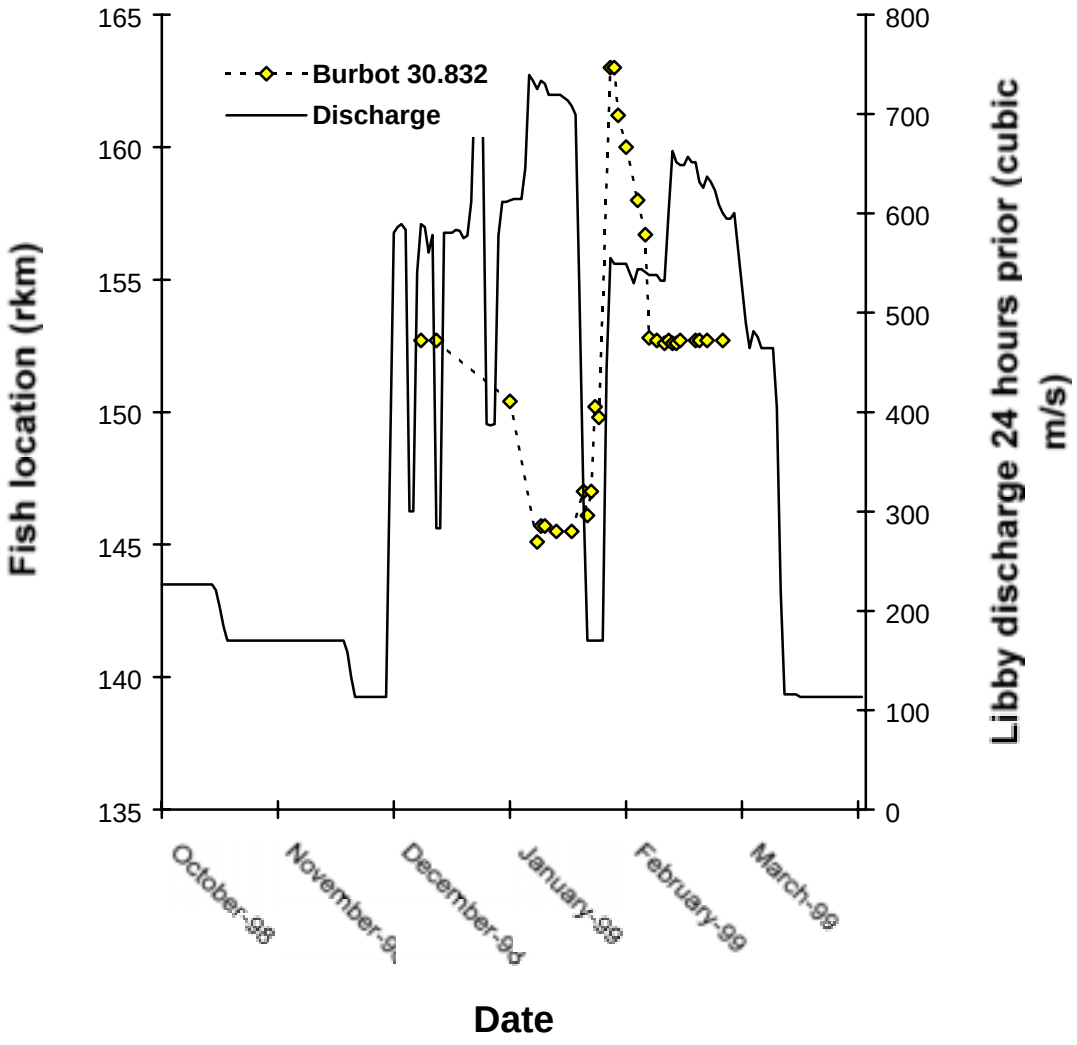

Figure 3. Kootenai River discharge at Libby Dam and movement of radio-tagged burbot 30.832 from October 1, 1998 through March 31, 1999.

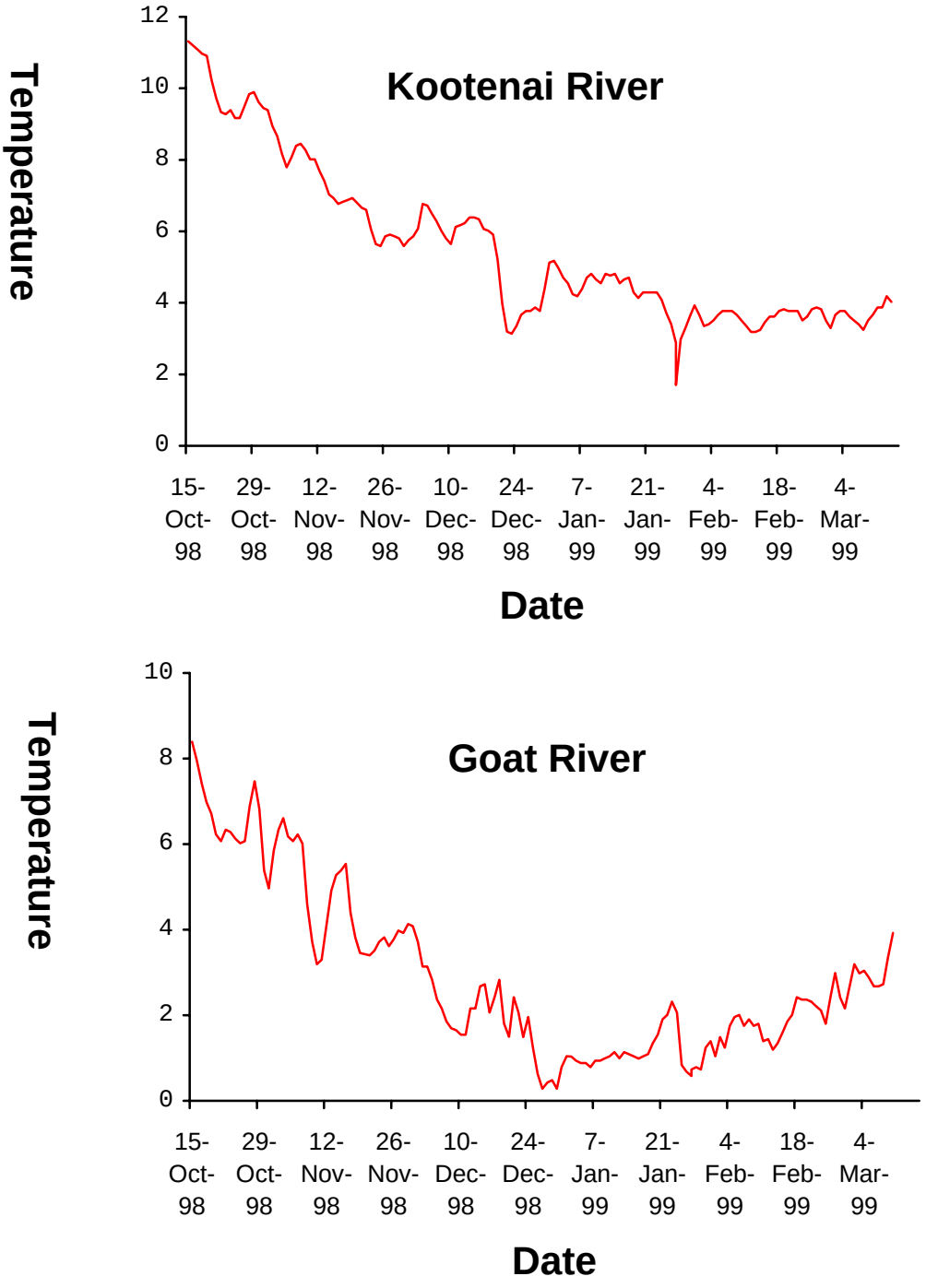

Figure 4. Average daily temperature of the Kootenai River at Porthill, from October 15, 1998 through March 14, 1999 and the Goat River, BC, from October 15, 1998 through March 10, 1999.

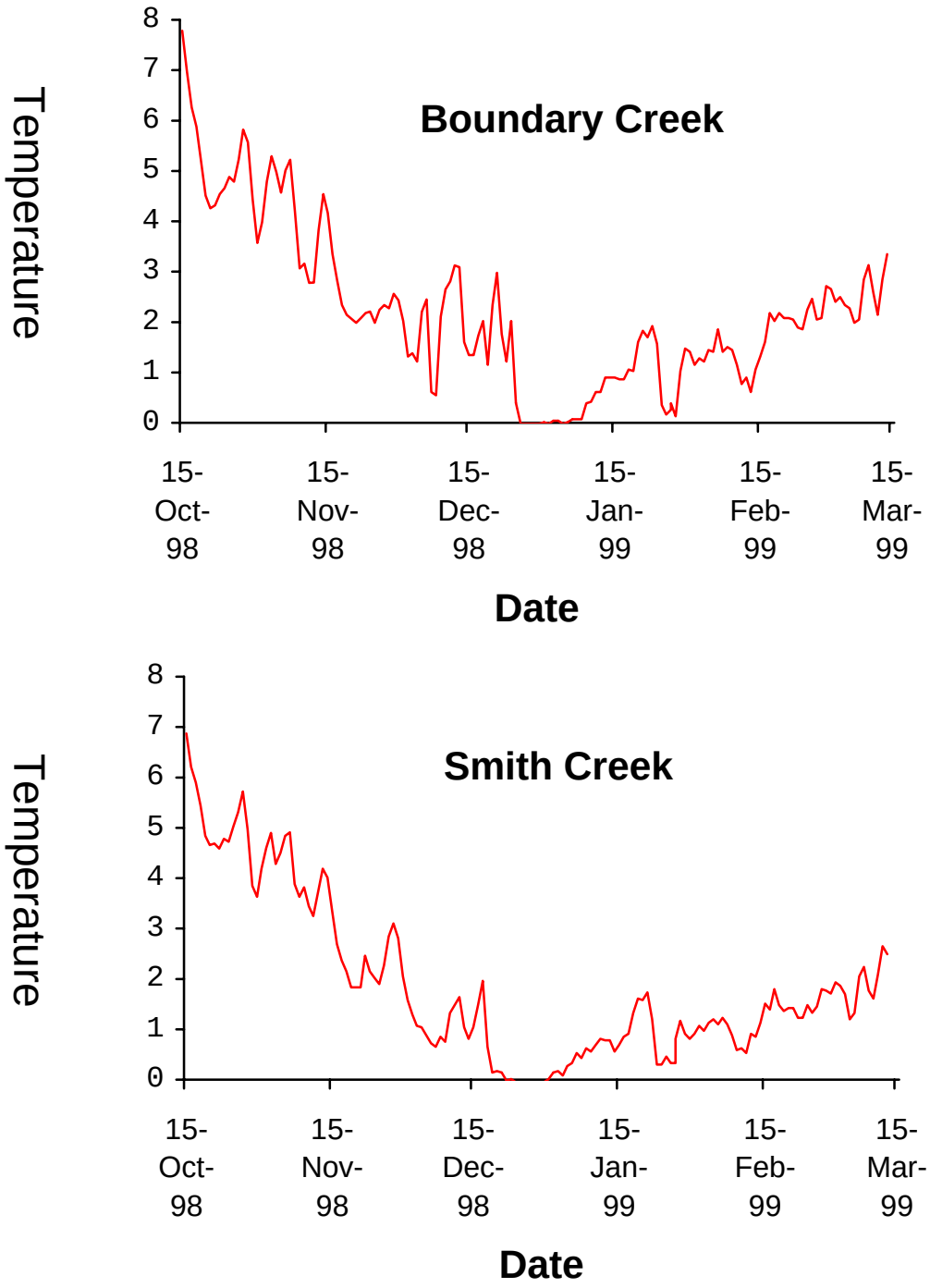

Figure 5. Average daily temperature of two Kootenai River tributaries in Idaho, October 15, 1998 through March 15, 1999; top figure is Boundary Creek and the lower figure is Smith Creek.

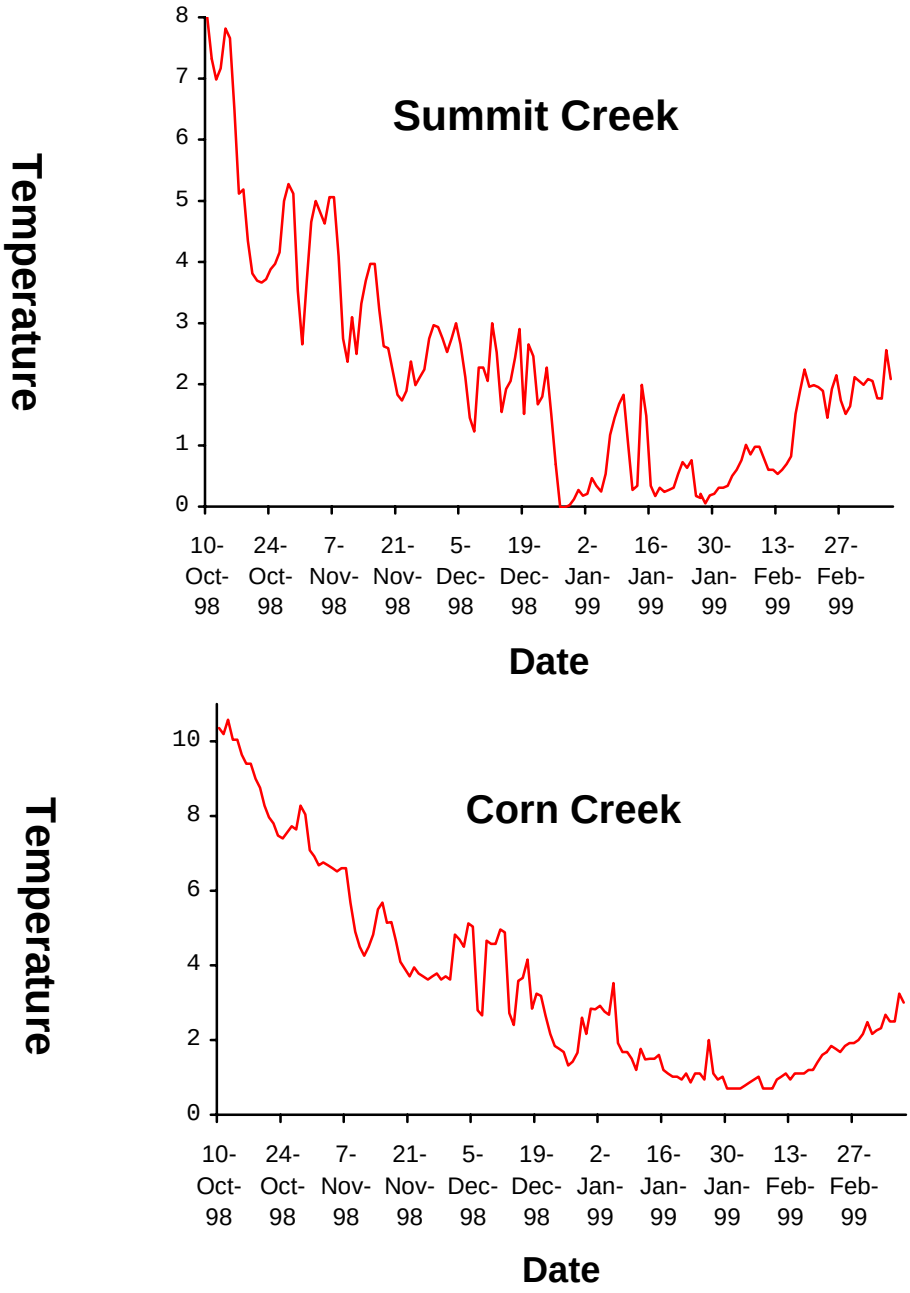

Figure 6. Average daily temperature of two Kootenai River tributaries in BC, Canada, October 10, 1998 through March 10, 1999; top figure is Summit Creek and the lower figure is Corn Creek.

Temperature of the Goat River was monitored October 15, 1998 through March 10, 1999 (Figure 4). The Goat River reached 0.0°C at noon on December 26, 1998 and the high temperature was 9.4°C on October 10, 1998. Thermographs monitored temperatures for Corn and Summit creeks in BC, tributaries to the Kootenai River, from October 10, 1998 to March 10, 1999 (Figure 6). Summit Creek temperatures ranged from 0.0°C in late December 1998 and early January 1999, to 8.6°C on October 10, 1998 (Figure 6). Corn Creek temperatures ranged from 0.7°C in January and February 1999 to 10.6°C on October 10, 1998.

Sampling Adult Burbot

Total Catch

We fished baited hoop nets from October 1, 1998 to April 12, 1999 for a total of 1,442 net days. A total of 185 aquatic animals were caught including 12 different species of fish and one species of crustacean (Table 1). Catch/unit of effort was 0.18 fish/net day for all species of fish combined and 0.03 fish/net day for burbot or one burbot/33 net days (Table 1).

Hoop Net Catch of Burbot

We captured a total of 44 burbot in Idaho and BC (Table 1, Figure 7). Fifteen burbot were caught in Idaho, including seven at Ambush Rock and two in Boundary Creek. The remaining 29 burbot were caught in BC, 23 in the Kootenay River and six in the Goat River. Burbot ranged from 363 mm to 803 mm TL (mean=541 mm, SE=2.43) (Figure 7) and weighed from 250 g to 3,125 g (mean=1,137 g, SE=15.21). Relative weights (W_r) ranged from 59 g to 132 g and averaged 91 (SE=0.36**).**

Several recaptures occurred during the 1998-1999 netting effort. Two burbot previously captured in the Goat River, BC (rkm 152.7) and marked with PIT tags during January of 1996, were recaptured in Idaho during the autumn of 1998, one at rkm 190.1 and the second at rkm 244.4. A third burbot first captured in the Kootenai River, at the mouth of the Goat River the previous winter, on January 4, 1998, was recaptured in the same location on December 4, 1998. A fourth recapture occurred when a burbot implanted with a sonic transmitter (sonic 445) at Nicks Island in BC (rkm 144.6) on December 7, 1998 was caught in a hoop net set in Boundary Creek, Idaho (rkm 170) on February 10, 1998, the transmitter was non-functional. Finally, a fifth burbot captured just outside the Goat River in the Kootenai River on December 9, 1998 was later observed and recaptured with a dip net in the Goat River during a spawning survey on the night of February 9, 1999.

Telemetry Studies

Twelve burbot were surgically implanted with sonic transmitters and radio transmitters from October 19, 1998 through January 18, 1999; four with radio transmitters and eight with sonic transmitters (Table 2). Five burbot were identified as males, four were females, and three were unidentifiable. Burbot ranged in TL from 507 mm to 775 mm and weights of 825 g to 2,760 g (Table

2). An additional female burbot had been tagged (sonic 592) with a transmitter the previous season but shed the transmitter or died in November 1998. This fish was tagged on December 31,1997 at rkm 149.9; it moved upstream into Idaho to rkm 205.5 then back down to the final location at rkm 203.3.

Burbot were located a total of 361 times from September 1, 1998 through August 31, 1999 (Appendices 1 through 13). Prior to the requested test, one sonic transmitter and two radio transmitters failed prematurely, two sonic tags were thought to have been shed, and two fish died prior to the test (Appendices 1 through 7).

Table 1. Hoop net catch by number, weight (kg), and catch per unit effort (CPUE)[a], for the Kootenai River and its tributaries in Idaho and BC, October 1, 1998 through April 12, 1999.

Species	Number	Total Weight (kg)	CPUE[a]
Pumpkinseed *Lepomis gibbosus*	1	0.05	0.0007
Brook trout *Salvelinus fontinalis*	1	0.06	0.0007
Bull trout *Salvelinus confluentus*	1	0.33	0.0007
Yellow perch *Perca flavescens*	3	0.30	0.0021
Mountain whitefish *Prosopium williamsoni*	3	0.41	0.0021
Rainbow trout *Oncorhynchus mykiss*	3	1.28	0.0021
Peamouth chub *Mylocheilus caurinus*	16	1.83	0.0111
White sturgeon *Acipenser transmontanus*	20	3.60	0.0139
Sucker[b] *Catostomus catostomus and C. macrocheilus*	23	5.95	0.0160
Northern pikeminnow *Ptychocheilus oregonensis*	67	26.55	0.0465
Burbot *Lota lota*	44	66.54	0.0305
Crayfish *Pasifastacus spp.*	3	0.30	0.0021
Total	185	107.20	0.1285

[a]A unit of effort is a single net set for 24 hours.
[b]Species of suckers were not always differentiated; however, longnose and largescale sucker species were identified in the catch.

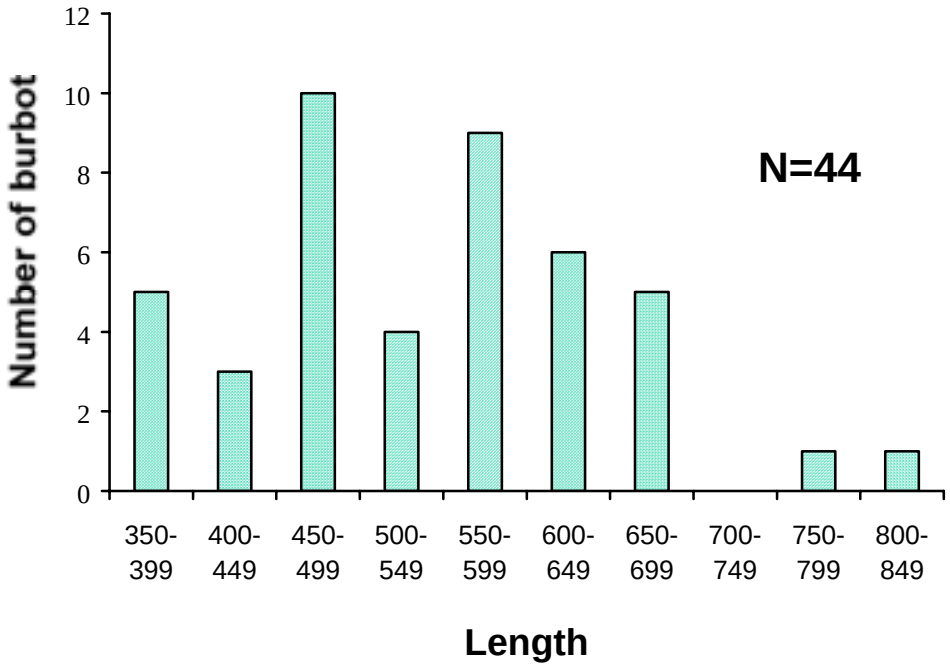

Figure 7. Length frequency distribution of burbot caught by baited hoop nets in the Kootenai River and its tributaries in Idaho and BC, October 1, 1998 through April 12, 1999.

Table 2. Summary of telemetry data and physical characteristics of 13 burbot in the Kootenai River, Idaho and BC, Canada, September 1998 through August 1999.

Transmitter Code	Release Date	Release Site (rkm)	Total Length (mm)	Weight (g)	PIT tag Number	Sex	Last date Located
592[a]	12/31/97	149.9	720	2,150	7F7D433107	F	8/31/99
289[b]	10/7/98	244.4	688	1,675	7F7D0A407E	M	1/28/99
238[a]	10/19/98	213.2	699	1,765	7F7D434279	M	8/31/99
3334[b]	11/11/98	190.3	553	1,500	7F7D0E0C5E	M	1/5/99
326[c]	12/4/98	149.2	662	2,260	7F7D042A33	--	2/6/99
30.832	12/11/98	152.7	590	1,075	7F7D090934	M	2/23/99
445[c]	12/7/98	144.6	641	1,765	7F7D3C4968	M	2/8/99
30.822	12/11/98	150.2	550	1,040	7F7D232A6F	F	3/9/99
30.812[c]	12/22/98	163.0	507	825	7F7D0D617D	F	1/17/99
2237	12/24/98	150.2	775	2,760	7F7D3E7612	F	2/23/99
252	12/31/98	159.0	658	1,645	7F7D0E4C2D	F	4/14/99
4245	1/11/99	151.5	560	1,100	7F7D04381B	--	2/9/99
30.100[c]	1/18/99	151.3	495	900	7F7D052550	--	1/19/99

[a]Transmitter was shed or fish died, same location since December 1998.
[b]Fish was found dead in shallow water.
[c]Transmitter failed.

Six burbot had active transmitters prior to the requested test flow (Appendices 8 through 13). The USACE provided a single five-day test period of 170 m^3/s beginning January 20, 1999 (Figure 3). On January 25, flow was ramped up reaching a maximum of 663 m^3/s on February 11, 1999. During the 5 d low flow period two burbot moved downstream and then upstream (Appendices 8 and 9), three moved 0.1 km or more upstream (Appendices 10, 11 and 12), and a sixth fish moved downstream more than 0.1 km (prior to the test this fish was on a downstream migration, Appendix 13). Burbot with radio tag 30.832 made the most distinguishable upstream migration during the low flow period, traveling 16.9 km and averaging 4.2 km/day (Figure 3 and Appendix 10). After flow was ramped up, burbot 30.832 moved downstream 10.4 km. Burbot with radio tag 30.822 followed a similar pattern as 30.832 by moving downstream (Appendix 4), then prior to the low flow moving upstream at about 0.3 km/day, then during the low flow period moving 2.2 km upstream or about 0.4 km/day (Appendix 6).

We obtained nose velocity measurements on 41 burbot locations from October 1, 1998 through March 17, 1999. A comparison of nose velocities, using a one-way ANOVA, during the low flow period January 20 to 24, 1999 (N = 12, SD = 4.22, and mean = 7.75 cm/s) and velocities before and after this interval (N = 29, SD = 14.82, and mean = 26.35 cm/s) indicated velocities were significantly lower during the low flow of 170 m^3/s (F = 0.0001). However, our sample size was restricted because the time devoted to radio telemetry made it difficult to also measure nose velocities.

Spawning and Postspawning Studies

Spawning Period

Our first record of a burbot migrating into the Goat River occurred about January 25, when the water temperature of the Goat River was <1^{o}C. A second burbot was caught January 29 and four more were caught between February 3 and 19. Two burbot were captured in Boundary Creek on February 8 and 23. At least three of six burbot with transmitters entered the Goat River during this period, radio transmitter 30.822 entered on February 8 and 30.832 on February 16. These radio-tagged burbot remained in the Goat River through at least March 9 and February 23, respectively, after which, radio contact was lost. Sonic tagged burbot 252 entered the Goat River about March 5 and reentered the Kootenai River by March 9.

Postspawn Period

Only one burbot (252) could be tracked during what we believe was the postspawning season. By April 14 it had moved downstream to rkm 146.4 and could not be located thereafter (Appendix 9). Sonic-tagged burbot 2237 moved to near the mouth of the Goat River but remained in the Kootenai River through February 23 when contact was lost. It is not known if this fish moved into the Goat River at times when we were not present.

Hoop net sampling in Idaho during March and April, during what we believe was the postspawn period, resulted in the capture of five burbot. Two were captured on March 13, 1999 at Ambush Rock (rkm 244.5), one was a ripe male (milt flow with handling); the second was of unknown sex. A third burbot was caught March 18; a biopsy revealed this was an unspawned female reabsorbing eggs. Two additional burbot of unknown sex were caught March 30 at Ambush Rock.

Larval Sampling

Paired ½ meter nets captured one larval burbot in the Kootenai River. The larval burbot was caught while on March 25, 1999 while towing in the muddy plume of the Goat River flowing into the Kootenai River (rkm 152.7-150.8). Water temperature in the Kootenai River on the date of capture was 6^{o}C. A total of 129 paired ½ meter net tows were made, averaging approximately 12 minutes each. Total towing time was 25 hours, 39 minutes, and 101,020 m^3 of water was filtered through the nets.

Population Estimate of Burbot

We calculated an estimated 540 adult burbot (SE = 753) were in the Kootenai River from Kootenay Lake, BC, (rkm 120) to Bonners Ferry (rkm 246) during the 1997 season. This estimate was based on the capture of 130 fish and the recapture of nine from autumn 1995 through spring 1999. We did not provide an estimate of survival or recruitment because our sample size was too small and the estimates lacked precision.

Duncan Lake Burbot Genetic Analysis

Preliminary analysis of 18 tissue samples of burbot from Duncan Lake, BC indicates 81% of the fish had the haplotype Bur-1. Additional analysis and data were not available at the preparation of this report.

DISCUSSION

Burbot in Idaho are near demographic extinction as evidenced by a population estimate of 540 fish (seven fish/rkm) in the lower Kootenai River. However, our population estimate of burbot does not as yet meet the minimum criteria for population estimates established by Robson and Regier (1964) where MC$\geq$ 4P. We believe that our continued efforts to mark and recapture burbot will improve upon this estimate and that it is still representative of a low-density population.

Catch per unit effort (CPUE) has been used to compare burbot stock densities (Parker et al. 1988). Burbot densities vary between river and lake-environments but CPUE in the Kootenai River for winter sampling is very low, ranging from one fish/18 net days to one fish/45 net days (Paragamian 2000). For comparison CPUE of burbot in four Alaskan Lakes ranged from one fish/two net days to three fish/one net day (Parker et al. 1988) while in the Tanana and Chena rivers it was >one fish/one net day and one fish/two net days (Evenson 1993). Based on these

comparisons the densities of burbot in exploited Alaskan fisheries appear to be 20 times greater, at a minimum, than the Kootenai River population.

Mitochondrial DNA analysis of burbot from Duncan Lake indicated these fish could be a suitable donor stock to aid in the recovery of burbot in the Kootenai River. The haplotype Bur-01 was dominant in the Duncan Lake samples, occurring in 80% of the samples. For comparison Paragamian et al. (1999) found the Bur-01 haplotype occurrence was 81% in the Kootenay Lake samples and 68% in Kootenai River samples. There were no natural barriers in the Duncan River prior to construction of Duncan Dam, and burbot in Kootenay Lake and Kootenai River could move freely into the Duncan Lake or River. In addition we believe it will be important to gain information on some of the spawning behavioral characteristics of burbot from Duncan Lake, including location of spawning, date/period of spawning, migration patterns, and temperature at spawning.

The five-day low flow provided by the USACE in January was too short in duration to achieve our objective. Our objective was to test the null hypothesis that winter operation of Libby Dam does not inhibit burbot migration distance or travel rate. Instead the low flow condition provided a duplication of the completed test conditions held during the 1997-1998 study (Paragamian 2000). Burbot behavior was not unexpected; there were several distinguishable upstream migrations during the low flow, and prior to the low flow some burbot demonstrated repeated responses of upstream and downstream movement similar to previous years (Paragamian 2000). For example, burbot with radio tag 30.832 traveled 16.9 km and averaged 4.2 km/day during the five days of 170 m^3/s. Burbot with radio tag 30.822 followed a similar pattern but moved only 2.2 km or about 0.4 km/day. Several other burbot did not move as often or as far. However, because our sample size was limited to only a few burbot we cannot judge this information to be representative of the population as a whole.

We examined average daily winter flows from Libby Dam to determine how frequently the USACE operated Libby Dam with flows of 128 m^3/s before burbot spawn compared to after they spawn. The protected minimum flow for the Kootenai River is 113 m^3/s and velocities suitable for adult burbot migration accompany flows below 283 m^3/s (Paragamian 2000). Flows during winter are seldom intermediate, between 128 and 708 m^3/s (Paragamian 2000). Average daily flows for October through mid-April for 1982 through 1994 were compared. We found that prior to spawning, flow in the Kootenai River exceeds 128 m^3/s about 81% of the time. However after burbot spawn, flows exceeded 128 m^3/s only 41% of the time. It is common for the USACE to meet their flood rule target elevation for Lake Koocanusa by early March then release only 113 m^3/s. This low flow period after burbot spawn may continue for several months. For example after burbot are believed to have spawned in the Goat River, during February 1999, flow from Libby Dam was gradually ramped down the first week in March 1999 to the minimum protected flow of 113 m^3/s. It remained at that level through June 14, 1999, when white sturgeon spawning flows were requested. The conservative flood rule curve system presently utilized by the USACE calls for evacuating most of the water from Lake Koocanusa during the burbot migration period in December and January.

The capture of unspawned females (reabsorbing eggs) and unspent males during the postspawn season has been common in the Idaho reach of the Kootenai River (Paragamian and Whitman 1996 and 1997). We believe high fluctuating flows from Libby Dam that have continuously disrupted burbot migrations (Paragamian 2000) may be responsible for the failure of spawning. The specific effect of this disruption to burbot spawning migration is unknown, but may have reduced spawning fitness, timing of spawning synchrony; it may also have influenced vitellegenin synthesis, and stress may contribute to ovulation failure, or reduced stamina. One or all of these possible reasons could have been sufficient to reduce spawning success and reduce sufficient

recruitment to sustain the fishery.

Each year several burbot are thought to have shed their sonic transmitters (Paragamian and Whitman 1996 and 1997). The recapture of a burbot in October 1998, previously implanted with a sonic transmitter in February 1996, provided us with no evidence of how the transmitter was shed. The incision of this recaptured burbot, previously tagged with sonic 1-2, had healed to the extent the incision could not be seen. Possible reasons for tag shedding could be the failure of sutures or the breakdown of suture material prior to healing. A burbot recaptured in 1996, a year after implant, still had the sonic tag in its body cavity with no evidence of rejection (Paragamian and Whitman 1997). Summerfelt and Mosier (1984) found that some channel catfish *Ictalurus punctatus* shed their sonic tags via transintestinal even though the incision had healed over. The tags were lost by enveloping the dummy sonic tag within the gastrointestinal wall then passing them through their rectal vent. Additional studies of channel catfish (Marty and Summerfelt 1986) confirmed transmitters were expuled either through the intestine, through the incision, or through a lesion, but about half of the fish retained transmitters for a longer period. A study of rainbow trout found similar results (Chisholm and Hubert 1985).

RECOMMENDATIONS

1. Test the null hypothesis that burbot migration distance or travel rate (distance/day) during the control treatment (hydropower production and floodwater evacuation) is not different than a test flow treatment of 170 m^3/s. Our findings indicated that the motivation for burbot to move the most is in January. Literature and our field observations suggest movement is related to spawning migration. We recommend a five-week test from January 10, 2001 through the second week in February 2001 during a flow of 170 m^3/s. The control period for our study would be the period of time before the test (primarily December).

2. Determine the distance traveled by burbot migrating from the lower Kootenai River (rkm 120 – 150) in January to estimate the necessary time needed for migrations to Boundary, Smith, and Parker creeks in Idaho. Travel time to reach the tributaries in Idaho would provide an estimate of the length of time for a lower flow necessary for an adequate migration period.

2. Capture and examine burbot in Idaho after the spawning season to determine whether or not they spawned and collect reproductive tissue samples to determine their state of maturity. This may provide evidence that burbot spawning synchrony has been disrupted by stress caused by high flows during vitellogenin synthesis or spermatogenisis.

4. Determine, under laboratory conditions, the effect of high velocities (>25 cm/s) and elevated winter temperatures on vitellogenin synthesis and the release of gonadotropin for egg ovulation. Field studies have shown that burbot caught in Idaho had sex products but failed to spawn. Failure to spawn may be stress-related and associated with high velocities or elevated temperatures of the Kootenai River during vitellogenin synthesis and/or release of gonadotropin for egg release.

5. Continue experimental larval burbot capture techniques with midwater trawls, sleds, beam trawls, shrimp net trawls, drop nets, meter nets, seine nets, etc.

6. Complete the mtDNA analysis of burbot tissue samples collected from Duncan Lake by BC MOELP in 2000. Burbot from Duncan Lake appear to be genetically similar to burbot in the Kootenai River and they may be a potential donor stock. In addition, it would be helpful if the BC MOELP fisheries staff were to obtain life history data on burbot in Duncan Lake. Data pertaining to location of spawning, timing of spawning, and migration patterns would be very important if this population were to be used as a donor stock.

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APPENDICES

Appendix 1. Location, date, velocity, water temperature, and depth of burbot 445 as determined by sonic telemetry, electronic current meter, and depth sounder.

Date	Location (rkm)	Depth (m)	Velocity (cm/s)	Water temperature (°C)
12/7/98[a]	144.6	11.6		
12/9/98	144.6	9.1		5.5
12/10/98	144.7			6.0
12/14/98	145.0	6.4		6.1
12/15/98	145.1	4.6		5.9
12/18/98	145.8	9.8		5.4
12/21/98	145.8	11.3		1.5
12/22/98	145.0	11.6		1.8
2/8/99[b]	170.0	3.0		

[a]Date of capture, sonic transmitter implant and release.
[b]Recaptured in Boundary Creek, transmitter had failed.

Appendix 2. Location, date, velocity, water temperature, and depth of burbot 30.812 as determined by radio telemetry, electronic current meter and depth sounder.

Date	Location (rkm)	Depth (m)	Velocity (cm/s)	Water temperature (°C)
12/21/98[a]	163.0	15.5		1.5
12/22/98[b]	163.0			
1/17/99[c]	145.5			5.0

[a]Date of capture.
[b]Date of radio transmitter implant and release.
[c]Transmitter failed.

Appendix 3. Location, date, velocity, water temperature, and depth of burbot 30.100 as determined by radio telemetry, electronic current meter and depth sounder.

Date	Location (rkm)	Depth (m)	Velocity (cm/s)	Water temperature (°C)
1/18/99[a]	151.3	12.8		4.5
1/19/99[b]	150.7			5.0

[a]Date of capture, radio transmitter implant and release.
[b]Transmitter failed.

Appendix 4. Location, date velocity, water temperature, and depth of burbot 238 as determined by sonic telemetry, electronic current meter and depth sounder.

Date	Location (rkm)	Depth (m)	Velocity (cm/s)	Water temperature (^{o}C)
10/19/98[a]	213.2	19.5		9.8
10/21/98	213.3	14.0		10.0
10/23/98	214.0	7.0		10.6
10/26/98	207.0	20.1		10.2
10/27/98	207.0	18.3	4.3	10.0
10/28/98	207.2	21.6		9.8
10/30/98	207.1	22.3		8.5
11/2/98	206.8	10.4		7.9
11/4/98	206.8	17.7		8.8
11/6/98	207.1	20.1		9.0
11/9/98	205.6	9.8		8.3
11/12/98	206.8	14.6		7.1
11/13/98	206.9	10.7		6.8
11/16/98	207.0	13.7		7.5
11/17/98	208.4	13.1		6.8
11/19/98	208.0	13.1		6.7
11/23/98	208.0	23.2		5.9
12/1/98	207.1	12.2		5.8
12/11/98	203.5	15.2		6.0
12/17/98	203.4	20.1		6.4
12/23/98	203.2	13.7		3.5
1/5/99	203.3	17.4		4.0
1/6/99	203.3	25.0		4.5
1/7/99	203.3	18.9	59	4.5
1/12/99	203.3	18.9		
1/13/99	203.3	15.2	16	5.0
1/14/99	203.3	23.2		5.0
1/19/99	203.3	20.4		5.0
1/20/99	203.3	19.8	8	4.6
1/21/99	203.3	19.2	10	4.9
1/22/99	203.3	13.4	10	4.9
1/25/99	203.3	19.2		3.8
2/1/99	203.3	21.3	21	4.8
2/2/99	203.3	19.8	23	4.0
2/6/99	203.3	18.3		
2/11/99	203.3	19.5		4.1
2/16/99	203.3	19.2		
3/7/99	203.3			3.5
3/14/99	203.3			4.5
4/7/99	203.3			
4/12/99	203.3			
4/19/99	203.3			
5/10/99	203.3			
6/4/99	203.3			
6/10/99	203.3			
6/24/99	203.3			
8/31/99	203.3[b]			

[a]Date of capture, sonic transmitter implant and release.
[b]Transmitter shed, or fish died.

Appendix 5. Location, date velocity, water temperature, and depth of burbot 592 as determined by sonic telemetry, electronic current meter and depth sounder.

Date	Location (rkm)	Depth (m)	Velocity (cm/s)	Water temperature (°C)
8/31/98 [a]	132.3			14.5
9/24/98	205.4			14.0
10/13/98	205.0	13.7		11.6
10/16/98	203.5	13.1		10.5
10/19/98	203.4			9.8
10/21/98	203.4	12.2		10.0
10/23/98	203.4	14.0		10.6
10/26/98	203.4	11.0		
10/27/98	203.4	13.7	6.7	10.0
10/28/98	203.4	13.7		9.8
10/30/98	203.4	10.1		8.5
11/2/98	203.4	14.6		7.9
11/4/98	203.4	11.9		8.8
11/6/98	203.3	13.7		9.0
11/9/98	203.3	12.5		8.3
11/11/98	203.4	15.2		7.0
11/12/98	203.3	17.4		7.1
11/13/98	203.3	13.7		6.8
11/16/98[b]	203.3	16.5		7.5
11/17/98	203.3	13.1		6.8
11/19/98	203.3	13.1		6.7
11/23/98	203.3	14.0		5.9
12/1/98	203.3	13.1		6.0
12/11/98	203.3	13.7		6.0
12/17/98	203.3	13.7		6.4
12/23/98	203.3			3.5
1/7/99	203.3	14.6	40	4.5
1/13/99	203.3	12.5	11	5.0
1/25/99	203.3	13.4		3.8
2/1/99	203.3	13.4	6	4.8
2/16/99	203.3	13.4		
3/7/99	203.3			3.5
3/21/99	203.3			
3/31/99	203.3			
4/7/99	203.3			
4/12/99	203.3			
4/28//99	203.3			
5/10/99	203.3			
5/18/99	203.3			
5/25/99	203.3			
6/2/99	203.3			
6/18/99	203.3			
8/31/99	203.3			

[a]Original date of capture, sonic transmitter implant, and release was 12/31/97 at rkm 149.9.
[b]Transmitter shed or fish died, no movement detected since November 1998.

Appendix 6. Location, date, velocity, water temperature, and depth of burbot 289 as determined by sonic telemetry, electronic current meter and depth sounder.

Date	Location (rkm)	Depth (m)	Velocity (cm/s)	Water temperature (^{o}C)
10/5/98[a]	244.4	19.5		11.0
10/7/98[b]	244.4			11.0
10/13/98	244.5	16.8		11.6
10/16/98	244.5	20.4		10.5
10/19/98	244.5	16.2		9.8
1/21/99	244.5	17.7		10.0
1/23/99	244.5	14.0		10.6
1/26/99	231.1	7.0		10.2
1/28/99[c]	217.1			9.8

[a]Date of capture.
[b]Date of sonic transmitter implant and release.
[c]Found dead on shoreline.

Appendix 7. Location, date, velocity, water temperature, and depth of burbot 3334 as determined by sonic telemetry, electronic current meter and depth sounder.

Date	Location (rkm)	Depth (m)	Velocity (cm/s)	Water temperature (^{o}C)
11/9/98[a]	190.1	20.4		9.0
11/11/98[b]	190.3			
11/12/98	190.5	10.1		7.1
11/13/98	192.5	12.2		6.8
11/16/98	194.8	7.0		7.5
11/17/98	191.7	11.9		6.8
11/19/98	174.5	10.4		6.7
11/20/98	161.5	17.7		
11/24/98	159.6	13.7		6.0
11/28/98	159.6	14.0		6.0
11/30/98	152.3	13.1		6.0
12/3/98	133.4	10.7		6.5
12/9/98	133.3	16.8		5.5
12/15/99	133.4	21.0		5.9
12/22/98	133.4	19.2		1.8
1/5/99[c]	119.1	1.2		4.0

[a]Date of capture.
[b]Date of transmitter implant and release.
[c]Found dead in Kootenay Lake.

Appendix 8. Location, date, velocity, water temperature, and depth of burbot 326 as determined by sonic telemetry, electronic current meter and depth sounder.

Date	Location (rkm)	Depth (m)	Velocity (cm/s)	Water temperature (^{o}C)
12/4/98[a]	149.2	18.0		5.8
12/7/98	149.8	17.1		6.0
12/9/98	150.7	21.3		5.5
12/14/98	150.8	21.9		6.1
12/15/99	150.9	21.0		5.9
12/18/98	151.3	9.8		5.4
12/21/98	150.9	20.7		1.5
12/22/98	150.9			1.8
12/28/98	151.0			2.8
12/30/98	150.9	11.7		5.0
12/31/98	150.9	18.3		
1/4/99	151.9	9.4		4.2
1/5/99	151.9	7.6		4.0
1/6/99	151.7	10.1		4.5
1/7/99	151.9	16.2	18	4.5
1/8/99	150.9	16.5		4.5
1/11/99	151.1	8.5		4.5
1/12/99	151.1	10.1		
1/13/99	151.2	7.6		5.0
1/15/99	151.1			5.0
1/17/99	151.0			5.0
1/18/99	151.3			4.5
1/19/99	151.3	7.9		5.0
1/20/99	151.3	7.9		4.6
1/21/99	151.3	6.7		4.9
1/22/99	151.0	12.2		4.9
1/23/99	151.1	8.5		4.0
1/24/99	151.4	7.3		4.0
1/25/99	151.3	9.1		3.8
1/26/99	148.4	9.4		3.5
1/27/99	151.1	9.8		3.5
1/28/99	150.5	8.8		3.0
1/29/99	151.1	8.2		3.8
2/1/99	151.1	8.5		4.8
2/2/99	151.1	8.2		4.0
2/3/99	152.7	13.7		4.0
2/4/99	152.7	11.9		4.0
2/6/99	151.3	6.1		

[a]Date of capture, sonic transmitter implant and release.

Appendix 9. Location, date, velocity, water temperature, and depth of burbot 4245 as determined by sonic telemetry, electronic current meter and depth sounder.

Date	Location (rkm)	Depth (m)	Velocity (cm/s)	Water temperature (^{o}C)
1/11/99[a]	151.5	13.1		4.5
1/18/99	150.9			5.0
1/19/99	150.8	19.8		5.0
1/20/99	150.7	26.5	13	4.6
1/21/99	150.3	25.3	1	4.9
1/22/99	150.7	21.6	4	4.9
1/23/99	150.7	20.7		4.0
1/24/99	150.7	26.2		4.0
1/25/99	150.7	25.0		3.8
1/26/99	150.6	25.3		3.5
1/27/99	150.8	18.0		3.5
1/28/99	150.8	20.1		3.0
1/29/99	151.8	19.2		3.8
2/1/99	152.2	19.2	38	4.8
2/2/99	152.2	22.6	31	4.0
2/3/99	152.2			4.0
2/4/99	152.3	14.9	33	4.0
2/6/99	152.3	13.4		
2/9/99	152.6	13.0	18	4.5

[a]Date of capture, sonic transmitter implant and release.

Appendix 10. Location, date, velocity, water temperature, and depth of burbot 30.832 as determined by radio telemetry, electronic current meter and depth sounder.

Date	Location (rkm)	Depth (m)	Velocity (cm/s)	Water temperature (^{o}C)
12/7/98[a]	152.7	13.4		
12/11/98[b]	152.7			
12/30/98	150.4	11.6		5.0
1/6/99	145.1			
1/7/99	145.7	9.8	34	4.5
1/8/99	145.7			4.5
1/11/99	145.3			4.5
1/11/99	145.8			4.5
1/15/99	145.5			5.0
1/18/99	147.0			4.5
1/19/99	146.1			5.0
1/20/99	147.0			4.6
1/21/99	150.2			4.9
1/22/99	149.8			4.9
1/25/99	163.0			
1/26/99	163.0			3.5
1/27/99	161.2	16.8		3.5
1/27/99	161.2			3.0
1/29/99	160.0			3.8
2/1/99	158.0			4.8
2/3/99	156.7			4.0
2/4/99	152.8			4.0
2/6/99	152.7			
2/8/99	152.6			4.5
2/9/99	152.7			4.5
2/10/99	152.6			
2/11/99	152.6			4.1
2/12/99	152.7			
2/16/99[c]	152.7			
2/17/99[c]	152.7			4.2
2/19/99[c]	152.7			4.2
2/23/99[c]	152.7			4.0

[a]Date of capture.
[b]Date of radio transmitter implant and release.
[c]Located 3-4 km up the Goat River.

Appendix 11. Location, date, velocity, water temperature, and depth of burbot 30.822 as determined by radio telemetry, electronic current meter and depth sounder.

Date	Location (rkm)	Depth (m)	Velocity (cm/s)	Water temperature (^{o}C)
12/9/98[a]	150.2	14.3		
12/11/98[b]	150.2			
12/15/98	152.0	10.1		5.9
12/21/98	151.4			1.5
12/22/98	152.3			1.8
12/28/98	151.7			2.8
12/30/98	151.9	14.6		5.0
11/4/99	151.5			
1/6/99	149.6			
1/7/99	148.6	7.6	28	4.5
1/8/99	148.6			4.5
1/11/99	149.5			
1/12/99	149.3			
1/15/99	149.5			5.0
1/17/99	149.5			5.0
1/18/99	150.2			4.5
1/20/99	151.5			4.6
1/21/99	151.8			4.9
1/22/99	151.9			4.9
1/23/99	152.3	13.7		4.0
1/24/99	152.4			4.0
1/25/99	151.7			3.8
1/25/99	152.0			
1/26/99	152.0			3.5
1/27/99	151.9			3.5
1/28/99	151.9			3.0
1/29/99	151.6			3.8
2/3/99	152.9			4.0
2/4/99	152.7			4.0
2/6/99	152.7			
2/8/99	152.7			4.5
2/9/99	152.5			4.5
2/10/99	152.6			
2/11/99	152.4			4.1
2/12/99[c]	152.7			
2/16/99	152.7			
2/17/99	152.7			4.2
2/19/99	152.7			4.2
2/23/99	152.7	1.8		4.0
2/26/99	152.7			
3/5/99	152.7			
3/9/99	152.7			

[a]Date of capture.
[b]Date of radio transmitter implant and release.
[c]Last eight locations were in the Goat River.

Appendix 12. Location, date, velocity, water temperature, and depth of burbot 2237 as determined by sonic telemetry, electronic current meter and depth sounder.

Date	Location (rkm)	Depth (m)	Velocity (cm/s)	Water temperature (^{o}C)
12/28/98[a]	150.2	14.0		2.8
12/30/98	150.6	15.2		5.0
12/31/98	150.6	18.3		
1/4/99	152.1	22.6		4.2
1/5/99	152.1	22.3		4.0
1/6/99	152.7	16.8		4.5
1/7/99	153.1	22.9		4.5
1/8/99	153.0			4.5
1/11/99	154.0			4.5
1/12/99	154.0			
1/13/99	154.1		51	5.0
1/15/99	154.1			5.0
1/17/99	154.1			5.0
1/19/99	154.3	9.8		5.0
1/20/99	154.4	13.3	11	4.6
1/21/99	154.4	12.2	10	4.9
1/22/99	154.4	11.6	8	4.9
1/23/99	154.5	14.6		4.0
1/24/99	154.6	11.0		4.0
1/25/99	154.6	12.5		3.8
1/26/99	154.6	12.5		3.5
1/27/99	154.6	13.1		3.5
1/28/99	154.5	12.2		3.0
1/29/99	154.5	9.4		3.8
2/1/99	154.5	18.0		4.8
2/2/99	154.4	18.3		4.0
2/3/99	154.3	12.2		4.0
2/4/99	153.1	13.4		4.0
2/6/99	153.4	14.3		
2/8/99	153.1	20.4	16	4.5
2/9/99	152.6	4.0	18	4.5
2/10/99	152.7	12.8	23	4.0
2/11/99	152.7			4.1
2/12/99	152.7	12.2		
2/16/99	152.7	12.2	36	
2/17/99	152.6	8.5	46	4.2
2/19/99	152.7	9.8		4.2
2/23/99	152.7	8.8		4.0

[a]Date of capture, sonic transmitter implant and release.

Appendix 13. Location, date, velocity, water temperature, and depth of burbot 252 as determined by sonic telemetry, electronic current meter and depth sounder.

Date	Location (rkm)	Depth (m)	Velocity (cm/s)	Water temperature (^{o}C)
12/31/98[a]	159.0	18.6		3.5
1/4/99	158.1	13.7		4.2
1/6/99	156.5	13.7		4.5
1/8/99	156.7			4.5
1/11/99	156.7	13.1		4.5
1/12/99	156.7	14.3		
1/13/99	156.3	12.2	51	5.0
1/15/99	156.2			5.0
1/17/99	156.2			5.0
1/20/99	155.8	20.4	13	4.6
1/21/99	155.8	22.6	2	4.9
1/22/99	155.8	22.3	3	4.9
1/23/99	155.3	13.1		4.0
1/24/99	154.5	12.5		4.0
1/25/99	154.4	18.3		3.8
1/26/99	154.2	16.5		3.5
1/27/99	154.0	13.1		3.5
1/28/99	154.0	12.2		3.0
1/29/99	154.0	15.8		3.8
2/1/99	154.5	11.3		4.8
2/2/99	154.0	11.0		4.0
2/3/99	154.0	13.7		4.0
2/4/99	152.3	14.9		4.0
2/6/99	152.3	13.4		
2/8/99	152.0	9.4	47	4.5
2/9/99	152.0	18.3	12	4.5
2/10/99	151.8	19.5	12	4.0
2/11/99	151.9	20.1	17	4.1
2/12/99	151.9	19.5		
2/16/99	151.9	20.7	26	
2/17/99	151.8	13.7	22	4.2
2/19/99	152.7	11.0		4.2
2/23/99	152.8	11.9		4.0
3/5/99[b]	152.7			4.0
3/9/99	151.9	8.8		4.5
3/11/99	151.7			5.0
3/15/99	151.7	10.7		5.1
3/18/99	150.8			
3/30/99	147.4			
4/6/99	147.4			
4/14/99	146.4			

[a]Date of capture, sonic transmitter implant and release.
[b]Located in the Goat River.

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